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TECHNICAL REPORT 3081

PRODUCT IMPROVEMENT STUDY
FOR
WARHEAD SECTION 318 MM ROCKET,
PRACTICE: M8E1

WILFRED TRURAN

COPY NO. 43 OF 54

OCTOBER 1963

PICATINNY ARSENAL
DOVER, NEW JERSEY

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TECHNICAL REPORT 3081

PRODUCT IMPROVEMENT STUDY
FOR
WARHEAD SECTION, 318MM ROCKET, PRACTICE: M8E1

BY

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OCTOBER 1963

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SECTION I

INTRODUCTION

This report covers the work performed by Picatinny Arsenal on product improvement of the M8E1 Warhead.

The M8E1 Warhead is the practice warhead for the Littlejohn Rocket System. The warhead is designed to have the same characteristics as the M146(T54E1) Tactical Warhead. It is used in place of the tactical warhead to train troops in usage, maintenance and handling.

The study was conducted by the Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota, under the direction of Picatinny Arsenal (PA). Twenty warheads were fabricated -- 10 were static fired and 10 were flight tested. All tests were successful. The 10 warheads statically fired were first subjected to shock, vibration and environmental tests.

The M8E1 Warhead utilizes one Fuze, Rocket, MT M421, and consists of the following three major assemblies: ogive assembly, forward assembly and rear assembly.

This study was to incorporate into the M8 R&D Practice Warhead, improved production processes and techniques, cost reduction, substitution of common T54E1 Tactical Warhead parts, where possible, and minor and major design improvements without sacrificing safety or reliability.

SECTION II

SUMMARY

The largest part of this study was accomplished under Contract DA-11-022-501-ORD-3582. Additional work was accomplished under Contract DA-11-022-ORD-4051.

In June 1960 negotiations between Minneapolis-Honeywell and PA were initiated for placing a production-engineering contract. In November 1960 Contract DA-11-022-501-ORD-3582 was signed. The contract called for the fabrication of four warheads with associated drawings, specifications and documentation.

The four units were completed and delivered to White Sands Missile Range, New Mexico (WSMR) in February 1961. The drawings, specification and applicable documentation were forwarded to Picatinny for implementation into a TDP.

Contract DA-11-022-ORD-4051, with Minneapolis-Honeywell, was signed in November 1961. This contract required performing additional tests on the new explosive train of the M8E1 Warhead (as installed in the warhead and without the warhead section) to be assured of its reliability. These tests included (1) a maximum-minimum gap and misalignment study of mild detonating fuze (MDF)-to-detonator and detonator-to-detonator initiation, (2) environmental tests using complete harnesses mounted to test boards, (3) rough handling tests of MDF, and (4) a prescribed series of handling shock, transportation and flight vibration and flight shock tests performed with complete explosive trains installed in warhead section.

SECTION III

CONCLUSIONS

The production-engineered M8E1 Warhead, using parts common to the tactical Warhead (T54E1), resulted in a reduction of cost over the M8 design through a savings in time to fabricate, cost of tooling and reduced material costs. The first year buy of the E1 design realized a savings of approximately \$1,200 per warhead over the first years' buy of the M8 design. The M8E1 unit cost was \$1,800 versus approximately \$3,000 for the M8. Thus a cost savings of 40% resulted from using the product-improved warhead in lieu of the R&D warhead.

Tests conducted on the explosive train showed that the gap between the explosive in the mild detonating fuze (MDF) and the base charge in the detonators should not exceed 0.002 inches. With the light explosive charge in the MDF (two grains per foot), the cross section of the core is extremely small (approximately 1/2000 of a square inch) and the explosive charge is not adequate to reliably initiate the base charge over a larger air gap. Appendix B contains test results.

SECTION IV

RECOMMENDATIONS

1. All future procurements should utilize the M8E1 design to realize the anticipated cost savings of approximately \$1,200 per warhead.
2. The M8E1 Warhead should be type classified as Standard A and assigned the nomenclature: Warhead Section, 318MM Rocket, Practice: M8A1. (Draft AMCTC was prepared to accomplish this.)

SECTION V

STUDY

It was decided that, whenever feasible, the M8E1 Warhead should utilize parts common to the production-engineered T54E1 Warhead. It was felt that components from the T54E1 production could be modified, thus allowing M8E1 units to be built under production conditions. Proceeding on this basis, a costly research and development program was eliminated. Another economic factor considered was a design utilizing production parts made on Government facilities and existing Government tooling and gaging.

Several innovations developed during the production engineering of the T54E1 Warhead were incorporated into the M8E1 design. These concepts included simplification of the fuze support bulkhead assembly by the use of an integral bulkhead in the forward skin; a cam-action fuze lockup device; a nose hold-down system using toggle-action latches; relocation of the break in the nose skin to Station 15.0; and modification of rubber shields to permit insertion of the mild detonating cord after bonding the shields.

The major components of the R&D M8 Warhead are the structural assembly, ballast assembly, mild detonating fuze assembly and cartridge assemblies.

These components are manufactured by the following methods:

1. The structural assembly is made up of aluminum skins and supporting frames fabricated from 6061 and 2014 aluminum in the T6 condition and formed by the roll and weld method and forging, respectively. The structure consists of three separable sections -- the forward section structural assembly, the mid section structural assembly and the aft compartment assembly.

The frame in the mid section structural assembly, located at Station 37.15, is machined from C1010 or C1020 steel bar. This frame also serves as the forward ballast weight.

The cast barrel holding the spotting charges, located in the aft end of the mid section, is cast from a Class 4C3 steel alloy in accordance with Specification QQ-S-681.

The aft compartment assembly, containing a steel ballast assembly, is cast from Class I steel in accordance with Specification QQ-S-681.

2. The MDF assembly consists of two lengths of MDF, approximately 33 inches long with two grains of PETN per foot; two forward detonators (DuPont Part No. X349), containing 1.1 grains of PETN attached to the ends of the MDF and bonded into a metal adapter along with a DuPont Detonator (Part No. X349) placed between the other two detonators; and one aft detonator containing four grains of PETN.

3. The two primer assemblies transmit the explosive wave from the aft detonator to the cartridge assemblies. The primer assembly consists of a threaded metal adapter containing a base detonator with approximately 2.2 grains of PETN (DuPont Part No. X346-C).

4. The cartridge assemblies, which indicate point of warhead event, are fabricated from copper tubing, copper sheet and laminated brass shim stock. Each assembly contains approximately 1.5 pounds of Spotting Composition 580.

In conducting this study several designs developed in the production engineering program on the T54E1 Warhead were incorporated into the M8E1 Warhead.

Skin, Nose (8836189)

The production-engineered nose skin is made from a nine inch-diameter by 0.375 inch-thick disc of 5154 aluminum alloy plate. This plate is preformed to a shallow, dimpled, dished cone. Then it is flow turned, trimmed and drilled to provide attachment holes for the nose ring assembly. Using this process and 5154 cold working alloy the desired properties of the skin are obtained without the distortion caused by heat treatment.

Forward Assembly (8849041)

This assembly extends from Station 15.0 to Station 38.75. The forward assembly incorporates the same fuze lockup and mounting system and the same nose hold-down mechanism as the production-engineered T54E1 model. (The M8 Warhead also adopted a similar method.) This assembly also contains portions of the MDF network bonded to the inside of the skin.

Skin, Forward (8836210)

The forward skin is also made by the flow turn process. A circular blank 15 inches in diameter is drilled and dimpled to form a 140° included angle, with a six inch-diameter flat for the integral bulkhead. The material is 0.687 inch-thick plate stock of aluminum alloy 6061-0, Specification QQ-A-327. The preform is flow turned in several steps, with solution heat treatment preceding the final contour flow turn. The material is then age hardened, trimmed, machined and drilled. Next the slots for the latch assemblies are pierced with a special punch and a dichromate conversion coating is applied to the skin as a protective finish.

Shield (8849061)

This part is the rubber longitudinal member containing MDF Assemblies 8849060 and 8850633. There are two shields per forward assembly, each bonded to the sides of the skin approximately 180° apart. The shields are approximately 19 inches long. They replace the two clamps utilized in the M8 design.

Latch Assembly (8836177)

The latch assembly used on the M8E1 is similar to the one adopted on the standard M8. Therefore, no description of the latch assembly will be included in this study.

Support, Fuze (8849055)

This part is a circular aluminum plate, alloy 2024-T4, Specification QQ-A-355, incorporating the seat for the fuze and adapter assembly. Two formed tabs hold the fuze base ring. This method of providing fuze locking tabs eliminates separate piece parts with subsequent assembly and adjustment. The fuze support is pierced, blanked, formed and drilled from aluminum. It replaces the machined casting of the standard M8 Warhead.

Rear Assembly (8849042)

The rear assembly contains a one-piece, sand-cast steel ballast which simulates the cargo weight of the tactical warhead. The ballast also provides two wells which hold the spotting charges. The rear assembly consists of the rear and base sections, the rear skin, the forward frame and portions of the MDF network with associated rubber shielding.

Shield (8849062)

Two extruded rubber shields provide support for the two mild detonating fuze assemblies (8849059). The shield is extruded from Class SC410, ABF2, or SC415, ABF2 rubber, Specification MIL-R-3065. The shields are cemented to the rear skin just aft of the forward frame with Synthetic Adhesive, Type 1, Specification MIL-A-13883.

Frame, Rear (8849045)

The rear frame forms the mating splice between the base assembly and the rear skin at Station 73.75. It is machined from aluminum alloy T7075, ASTM B209, and acts as a support for the aft end of the ballast.

Ballast (8849050)

The ballast is a one-piece machined steel sand casting. The holes for the primer assemblies and spotting charges are machined on the side of the ballast 180° apart.

Skin, Rear (8849054)

The rear skin has an ogival contour which becomes cylindrical at Station 50.0. The skin is fabricated by explosive forming from a rolled and welded preform of aluminum alloy coil stock, 6061-0, Specification QQ-A-327. The completed skin is heat-treated to condition T6. The hole patterns are drilled in an indexing drill, and counter-sink fixture which orients the part with respect to the hole pattern maintained in mating parts through correlated tooling. The two 3.85 inch-diameter holes in the skin used for the Cartridge Retaining Assembly (8849047), are cut 180° apart on the side of the rear skin with a special chasis punch-type tool.

The base and rear sections of the M8E1 Warhead use three parts for the structural components in contrast to four parts for the standard M8. In the M8E1 version the base, rear frame and rear skin replace the Station 79.0 Frame, the aft section skin, the Station 50.0 Frame and aft mid-section skin.

During mass production, a set of special drilling and counter-sinking fixtures would be used to drill holes for the 48 screws which fasten the rear frame of the rear assembly to the base. Correlation of this tooling, with respect to mating hole locations, assures that all parts are interchangeable and can be selected at random after metal finishing, thus permitting assembly into units with uniform dimensional characteristics.

Ten warheads were fabricated under this part of the study. These warheads were flight-tested at WSMR during October 1961. The flights were satisfactory except for ejection of some of the spotting charges.

The second phase of the study consisted of additional tests to prove out the new explosive train design.

The test program covered three broad areas -- a maximum-minimum study to determine extremes of spacing and misalignment between succeeding explosive components of the explosive train; propagation tests of explosive trains without warhead after being subjected to extreme temperatures (-80° and 160°F); and propagation of explosive trains installed in warheads after subjection to a series of vibration and shock environments.

MAXIMUM-MINIMUM STUDY

To conserve material and time, both aspects of the problem of spacing and misalignment were investigated simultaneously. Maximum air gaps and axial misalignment as well as MDF-to-boosters and booster-to-MDF propagation were studied in the same test set-up by coding of ends and selective assembly of the explosive trains to test boards. The test units consisted of lead sheath and plastic covered MDF containing two grains per foot of PETN. One foot-sections were cut and crimped to detonators (8824399) with various predetermined gaps between the core of the MDF and PETN base charge of the detonator. The assemblies were submitted to X-ray examination to determine the air gap between the core of the MDF and the base charge in the detonators.

X-raying of the assemblies was accomplished with a standard X-ray set having a 135 KV rating. Examination of the films and measuring of the gap between the MDF and the base charge was accomplished on a Bausch and Lomb Optical Contour Projector, Type 33-12-01. A 10-power magnification was employed to permit correct interpretation of the image and measurement of the gap within 1/1,000 of an inch.

After X-raying and measuring gaps, the assemblies were fastened to aluminum aligning blocks. Two blocks were clamped in a vise so the ends of the detonators were opposite, separated by a fixed distance and out of axial alignment by a predetermined dimension (Figure 7). The vise and the MDF tails were taped to a 0.020-inch aluminum sheet. Similar tests were conducted with a center block, two MDF assemblies and two base detonators (Figure 8).

A Number 6 electric blasting cap was fastened to one end of the MDF and initiated. The functioning of the MDF and detonator left impressions in the aluminum witness plate. By exploring propagation of detonation from blasting cap-to-MDF, thence to the first detonator through the air gap, to the second detonator on to the second MDF, the critical values for each of these separations were found over a wide range of values. It was found that a gap of $0.000 + 0.002$ inch between the MDF and detonator, a 1/4-inch gap with 3/16-inch axial misalignment between detonators at skin gaps, and a 0.058-inch gap with no axial misalignment between the (8824399) detonator and a 0.023-inch gap with a 0.0375-inch axial misalignment between the (8824399) detonators and (8823940) detonators in the ballast were satisfactory. The drawing tolerances allow all of these parts to fall well within these limits.

PROPAGATION TESTS OF EXPLOSIVE TRAINS WITHOUT WARHEAD

After values for the extremes of spacing and misalignment of consecutive components for the explosive train were established in the minimum-maximum study, 50 complete harnesses were built with the gaps and misalignments between succeeding explosive components adjusted to the minimum value (Type B) and 50 harnesses with the gaps and misalignments adjusted to the maximum value (Type A).

The harnesses were installed on composition board platform to which four aluminum blocks were mounted. One block represented the fuze adapter of the warhead into which three detonators were installed in the same arrangement as in the warhead. One of the detonators was part of the ORD 8849060 MDF assembly, one was part of the ORD 8850633 MDF assembly, and the third detonator (ORD 8834433) located between the above two, served as the booster.

The detonator on the other end of MDF assembly (ORD 8849060) was inserted into a second block and fastened. Similarly, the detonator on the other end of MDF assembly (ORD 8850633) is screwed into a third block. The sleeved end of one MDF assembly (ORD 8849059) was inserted into the opposite side of the block in which the second detonator of MDF, ORD 8849060 was inserted into and the other end of ORD 8849059 was inserted into one of four holes in a block that simulated the hook-up of the harness in the ballast section. In a like manner, the second ORD 8849059 was installed on the board with the second detonator coming into the hole in the four-way block opposite the one used by the detonator on the first assembly. Then two base detonators (ORD 8824398) were inserted in the remaining two holes opposite each other, in the block simulating the ballast section.

The values for Type A boards were: axial misalignments of 0.064-inch in the blocks simulating the skin breaks, with the face-to-face separation between the shells kept at 0.134 inch. In the block simulating the ballast, the detonators of the ORD 8849059 assemblies were axially aligned, but separated by an air gap of 0.058 inch. The axis of the two base detonators (ORD 8824398) were aligned 0.0375-inch below the longitudinal axis of the other two detonators. The faces of the base detonators were separated by gaps of 0.023 inch from the respective side of the shells of the MDF assembly detonators.

The Type B harnesses, the gaps and misalignments between explosive components were adjusted to a minimum value.

Under Step 1 of the propagation tests, 25 boards of Type A and 25 boards of Type B were destructively tested. The firings were performed at ambient temperature, or $70^{\circ}\pm 20^{\circ}\text{F}$. The findings are in Table 3.

Under Step 2, 10 boards of each type were conditioned at -80°F for 48 hours and then -65°F for 24 hours, prior to being fired. The results of these tests are in Appendix B.

Under Step 3, 10 boards of each type were subjected to simulated desert conditions of high temperature and low humidity in thirty 24-hour cycles, as follows: raise temperature from 90°F to 160°F in two hours; maintain at 160°F for 10 hours; decrease temperature from 160°F to 90°F for 10 hours. The relative humidity during these cycles was not more than 15%.

After the thirtieth cycle, the boards were initiated at 90°F . The test results are in Table 5.

The initiation of the explosive trains under all three steps was accomplished by initiating a Number 6 electric blasting cap, placed against the faces of the three detonators in the simulated adapter block.

PROPAGATION TESTS OF EXPLOSIVE TRAINS INSTALLED IN WARHEADS

For this portion of the test program, five sets of Type A explosive trains and five sets of Type B were installed in warheads and subjected to a series of shock and vibration tests (Appendix C).

Two of the warheads with the Type B trains were subjected to the transportation-vibration and flight-vibration tests. After the vibration tests, the units were inspected visually for indications of external or internal structural failure. Later the warheads were static fired successfully.

Two warheads with Type A explosive trains were tested in the same manner, also with satisfactory results.

Next, three warheads with Type A and three warheads with Type B explosive trains were subjected to the handling shock tests. One warhead with a Type A and one with a Type B train were also subjected to transportation-vibration and flight vibration tests, after the handling shock test. Then all six warheads were tested under flight shock conditions and after the necessary inspections were completed, their explosive trains were successfully initiated. The pertinent details of these tests are described in Appendix C.

APPENDICES

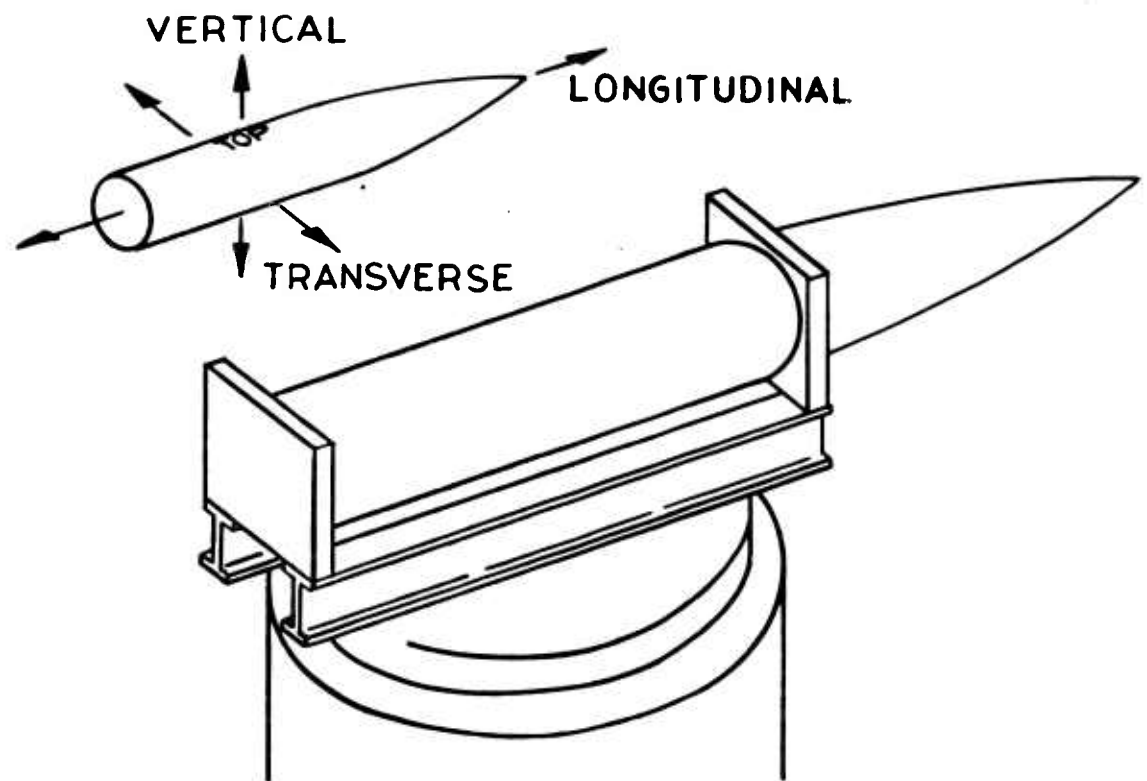
APPENDIX A

FIGURES

TEST PROGRAM SCHEDULE

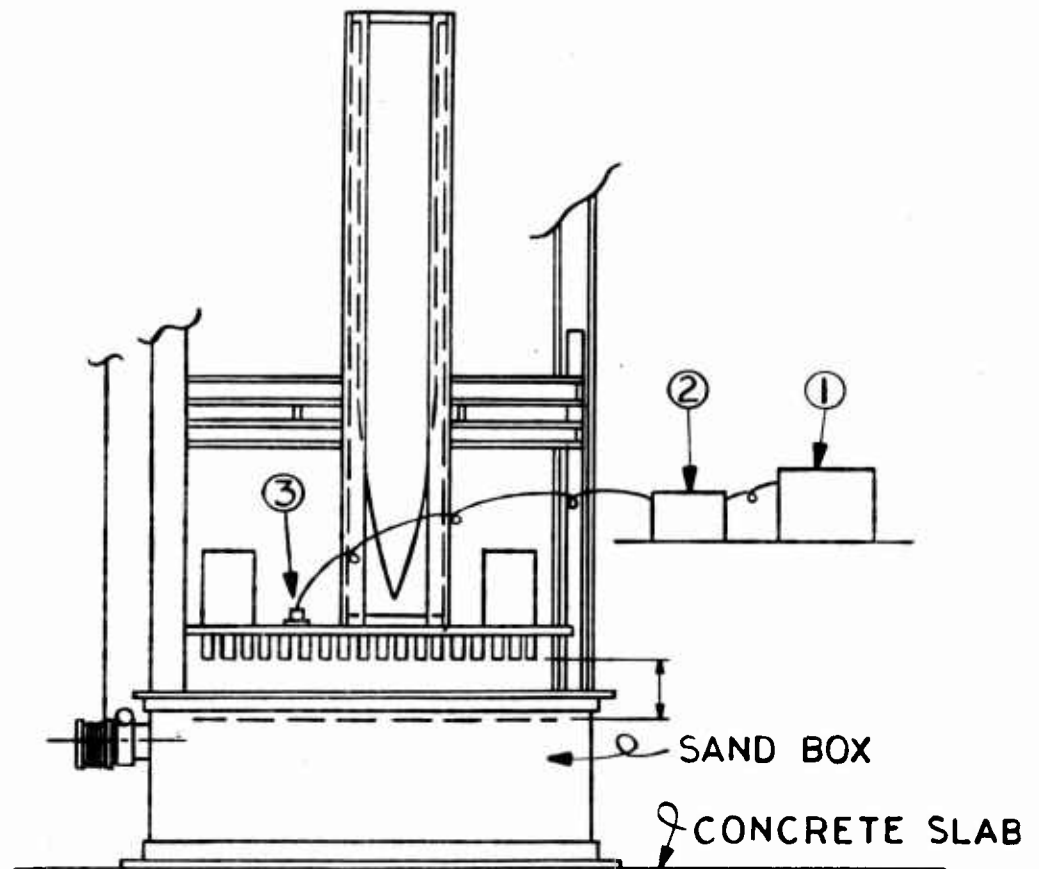
TEST	WARHEAD SERIAL NUMBER									
	5-3	5-4	5-5	5-1	5-2	4-1	4-2	4-3	4-4	4-5
HANDLING SHOCK	X	X	X			X	X	X		
TRANSPORTATION VIBRATION	X			X	X	X			X	X
FLIGHT VIBRATION	X			X	X	X			X	X
FLIGHT SHOCK	X	X	X			X	X	X		

Figure 1



AXES ORIENTATION OF WARHEAD
for
SHOCK and VIBRATION TESTS

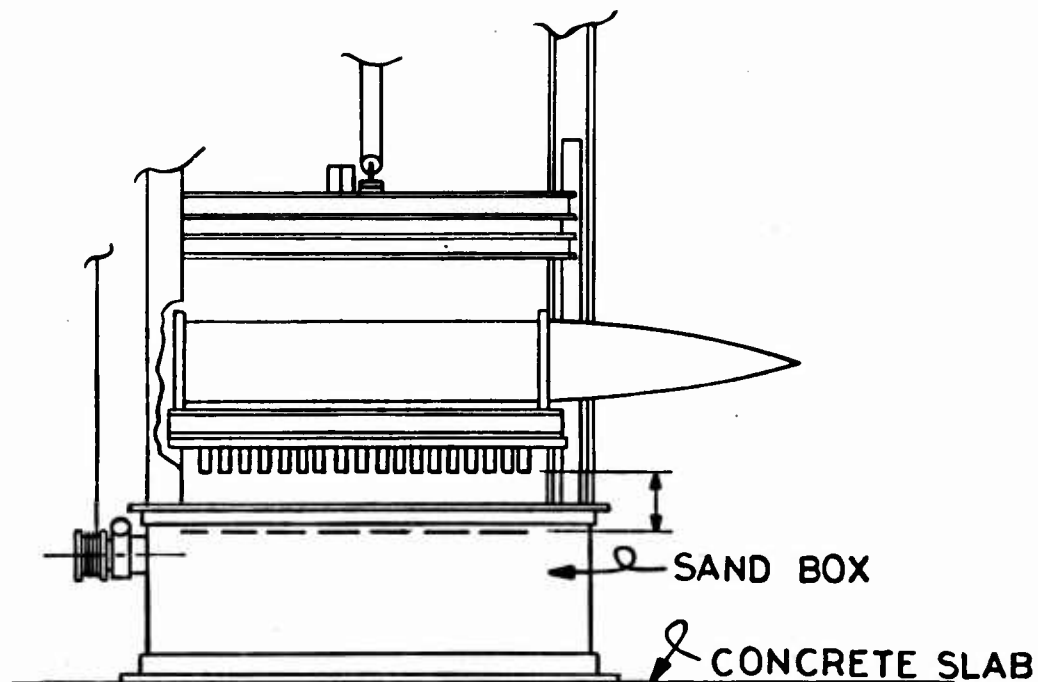
Figure 2



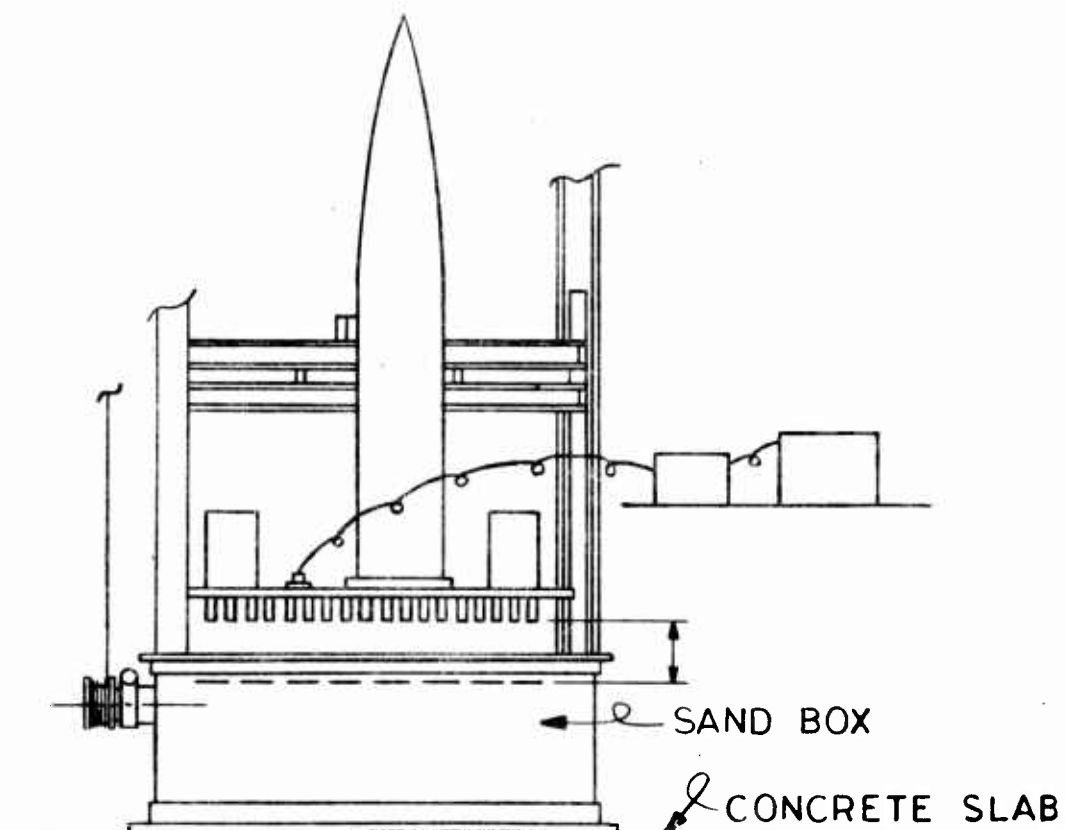
- ① OSCILLOSCOPE
- ② AMPLIFIER
- ③ ACCELEROMETER

HANDLING SHOCK
LONGITUDINAL AXIS-NOSE DOWN

Figure 3

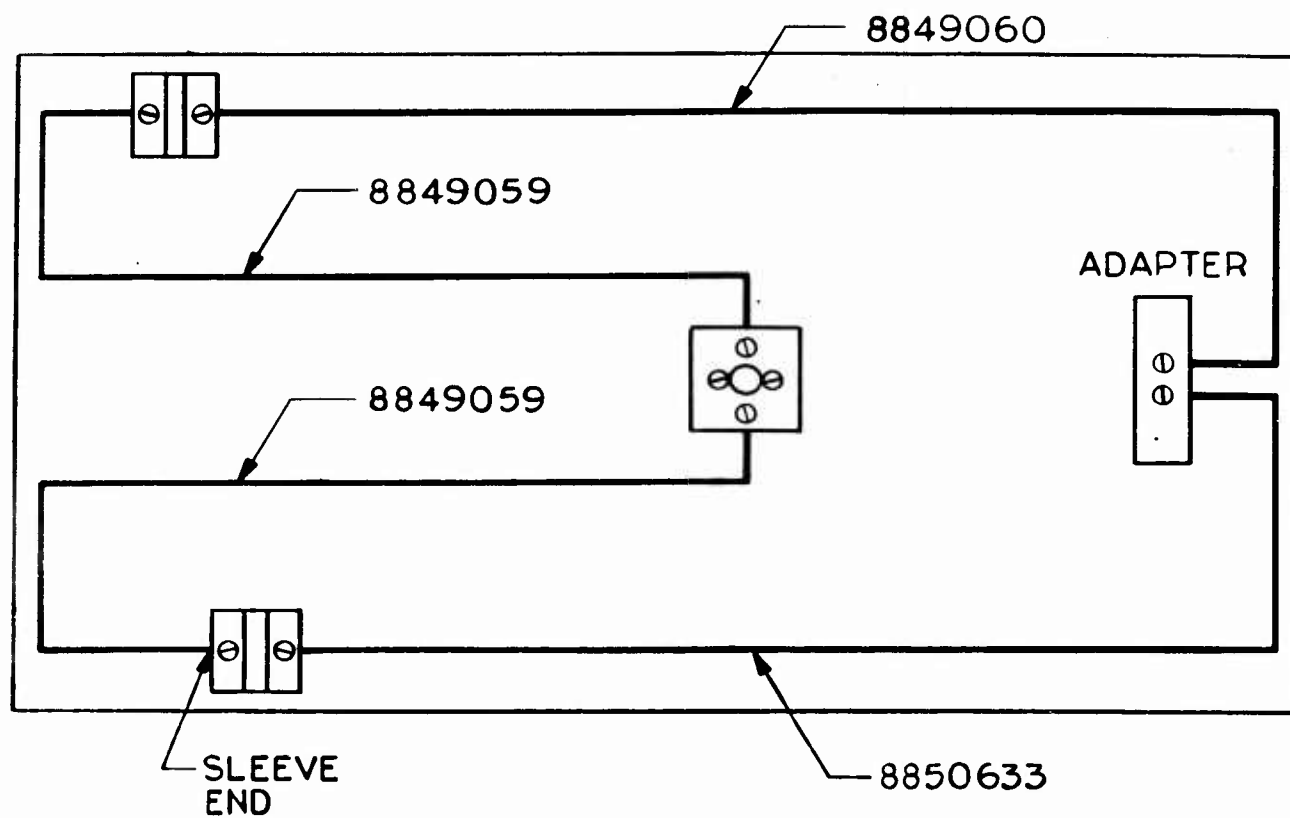


HANDLING SHOCK
VERTICAL and TRANSVERSE AXES



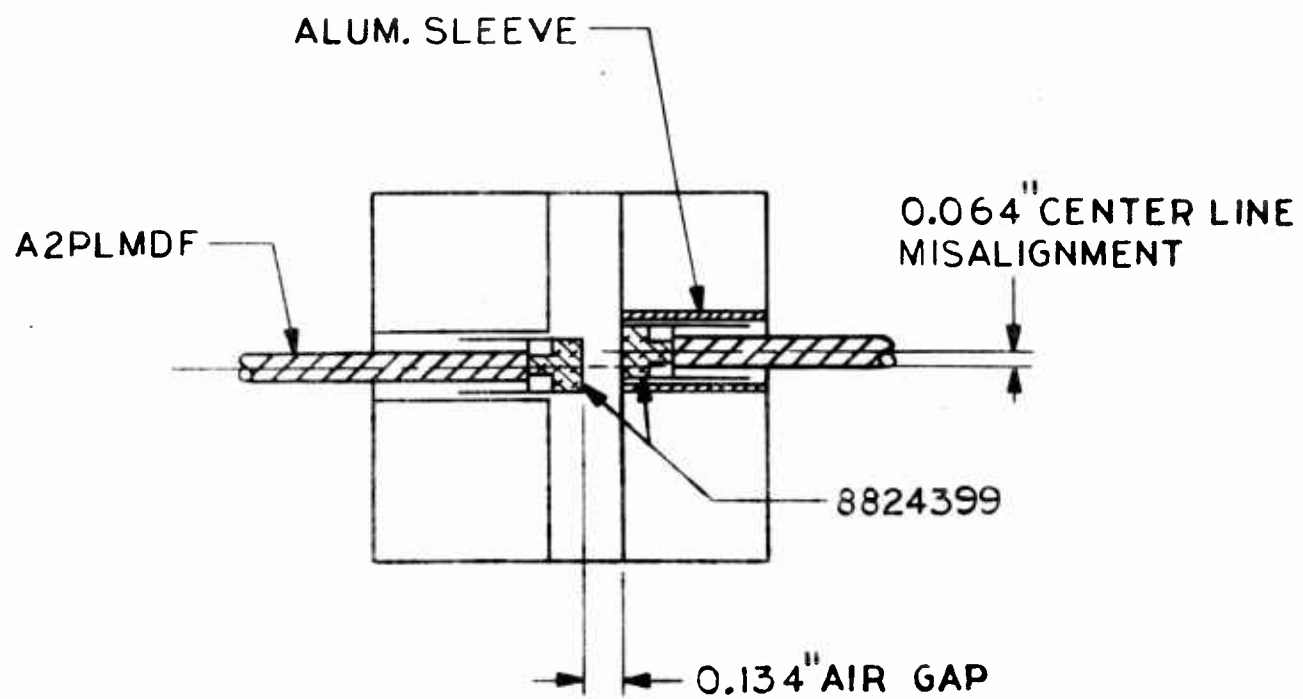
HANDLING SHOCK
LONGITUDINAL AXIS-NOSE UP

Figure 5



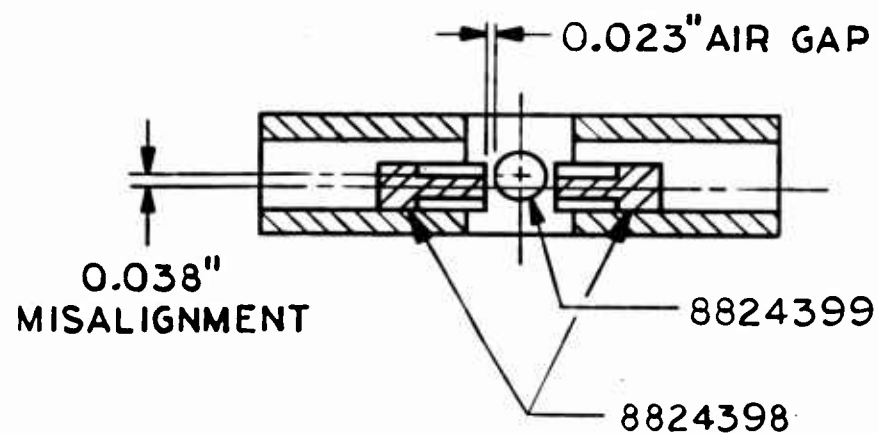
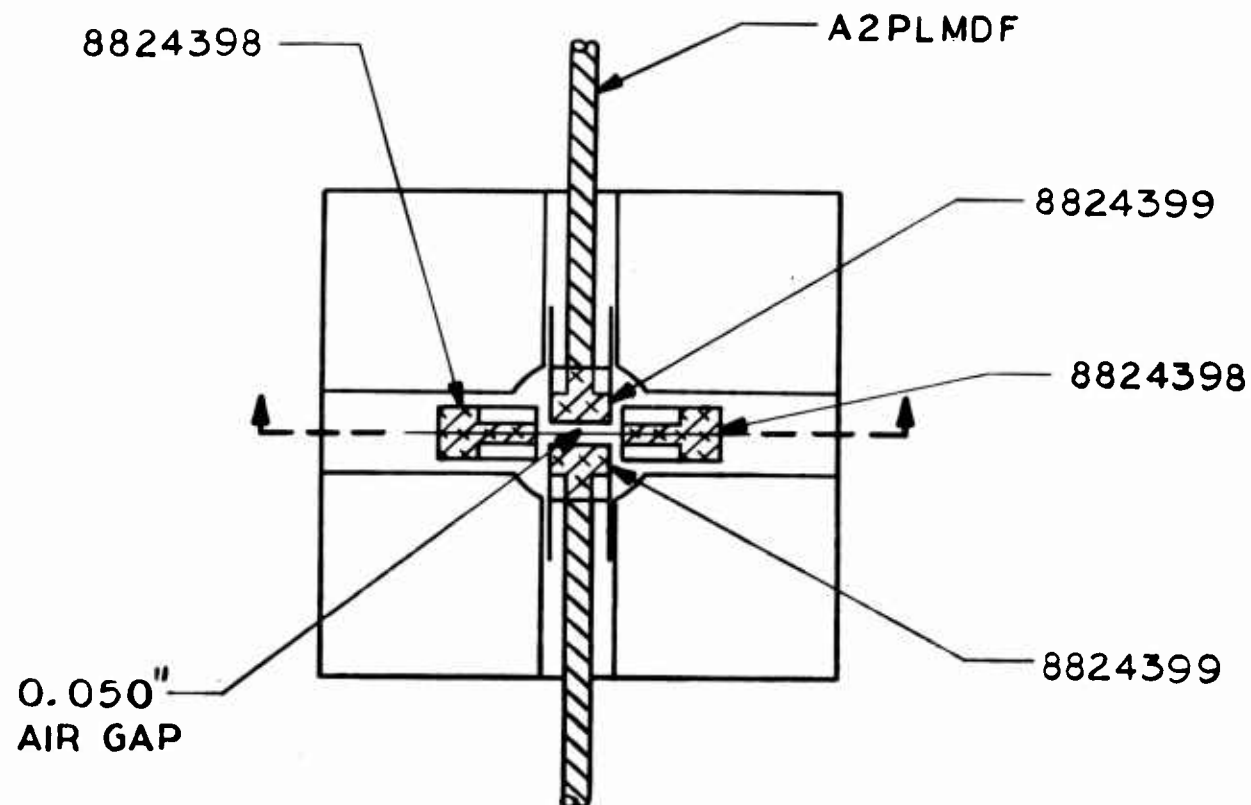
TEST BOARD BEFORE INITIATION OF EXPLOSIVE TRAIN

Figure 6



BOOSTER TO BOOSTER BLOCK

Figure 7



SIMULATED BALLAST BLOCK

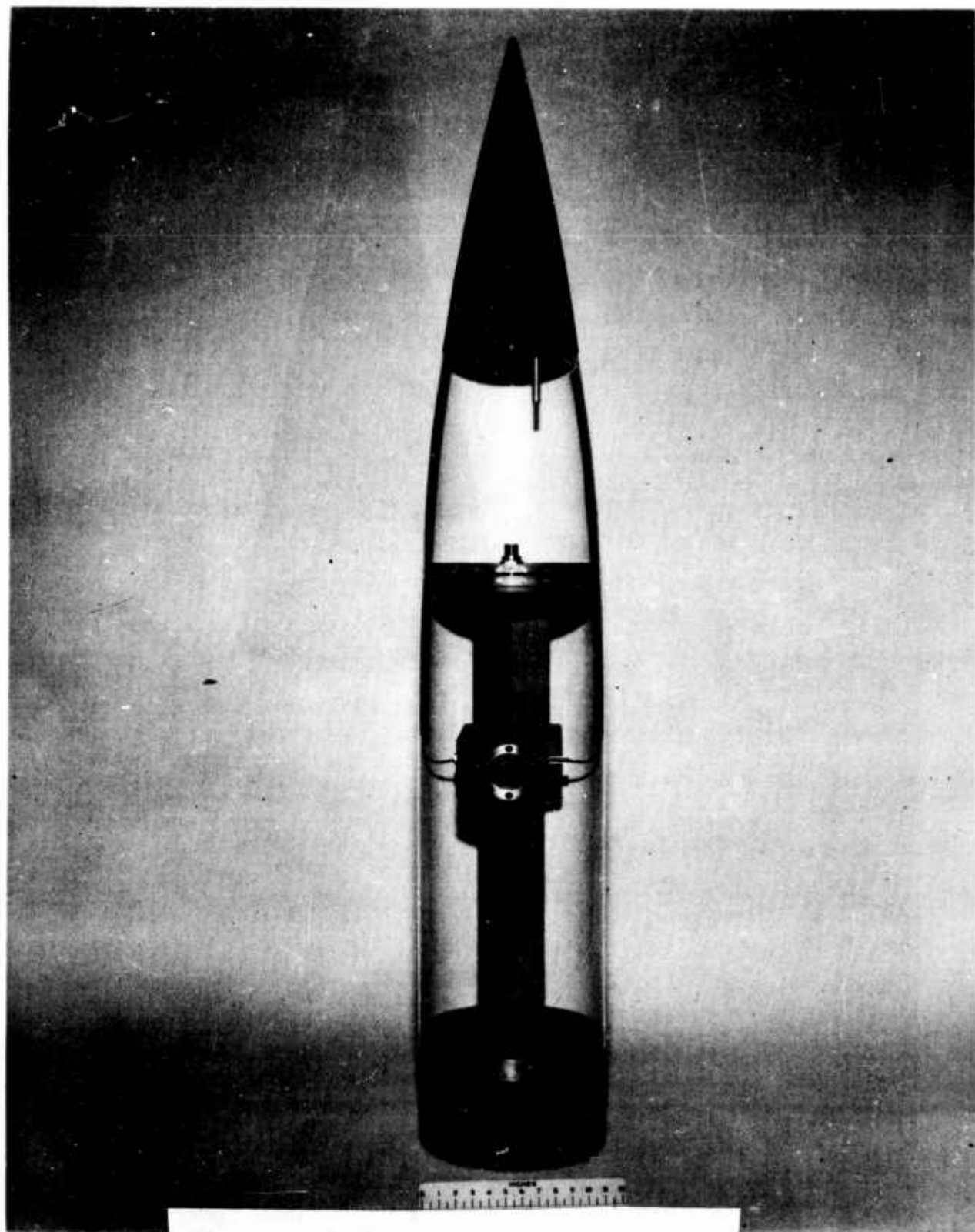


Figure 9. Sectioned Model of M8E1 Warhead

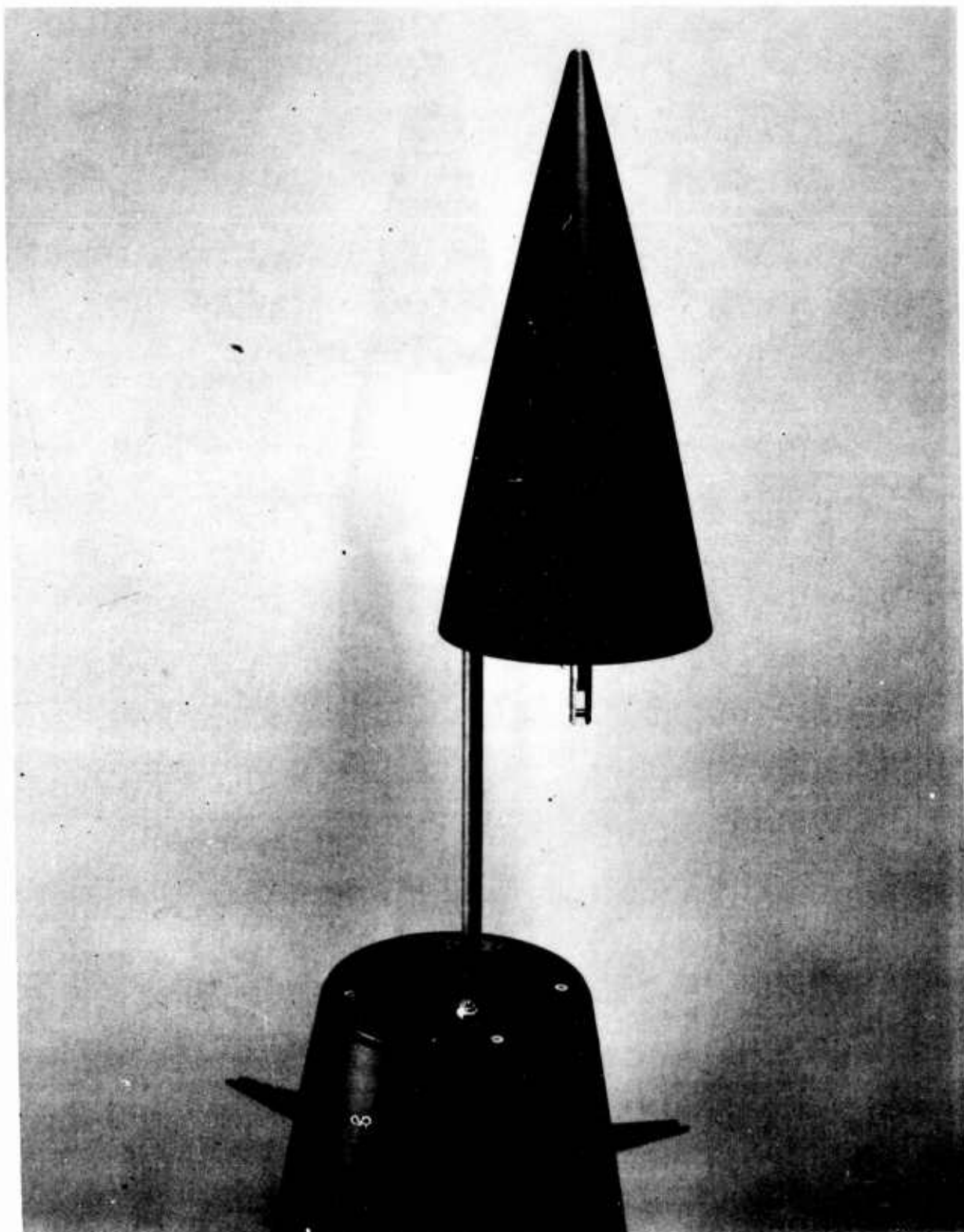


Figure 10, Rocket Ogive in the Opened Position

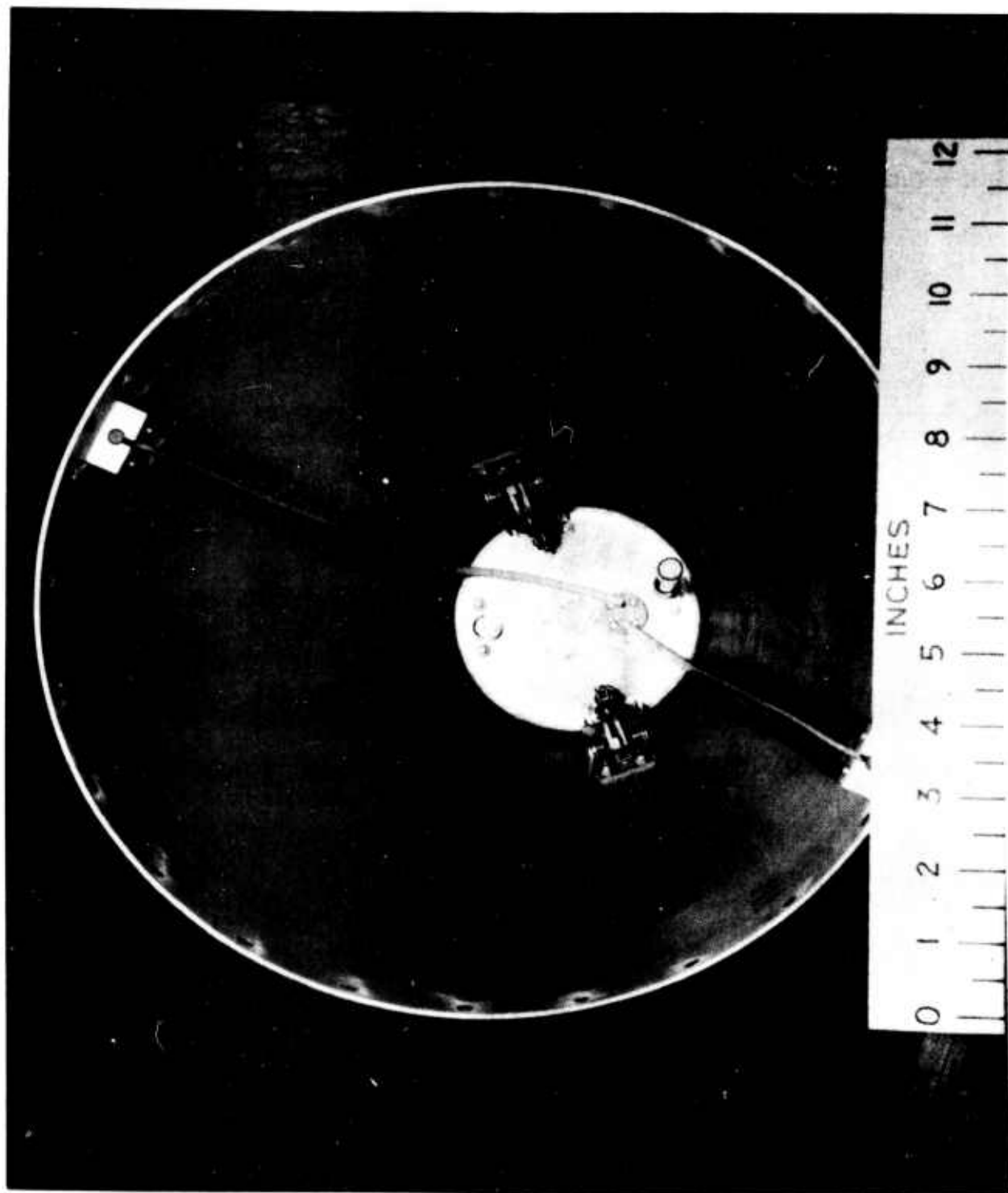


Figure 11, Internal View of Forward Assembly

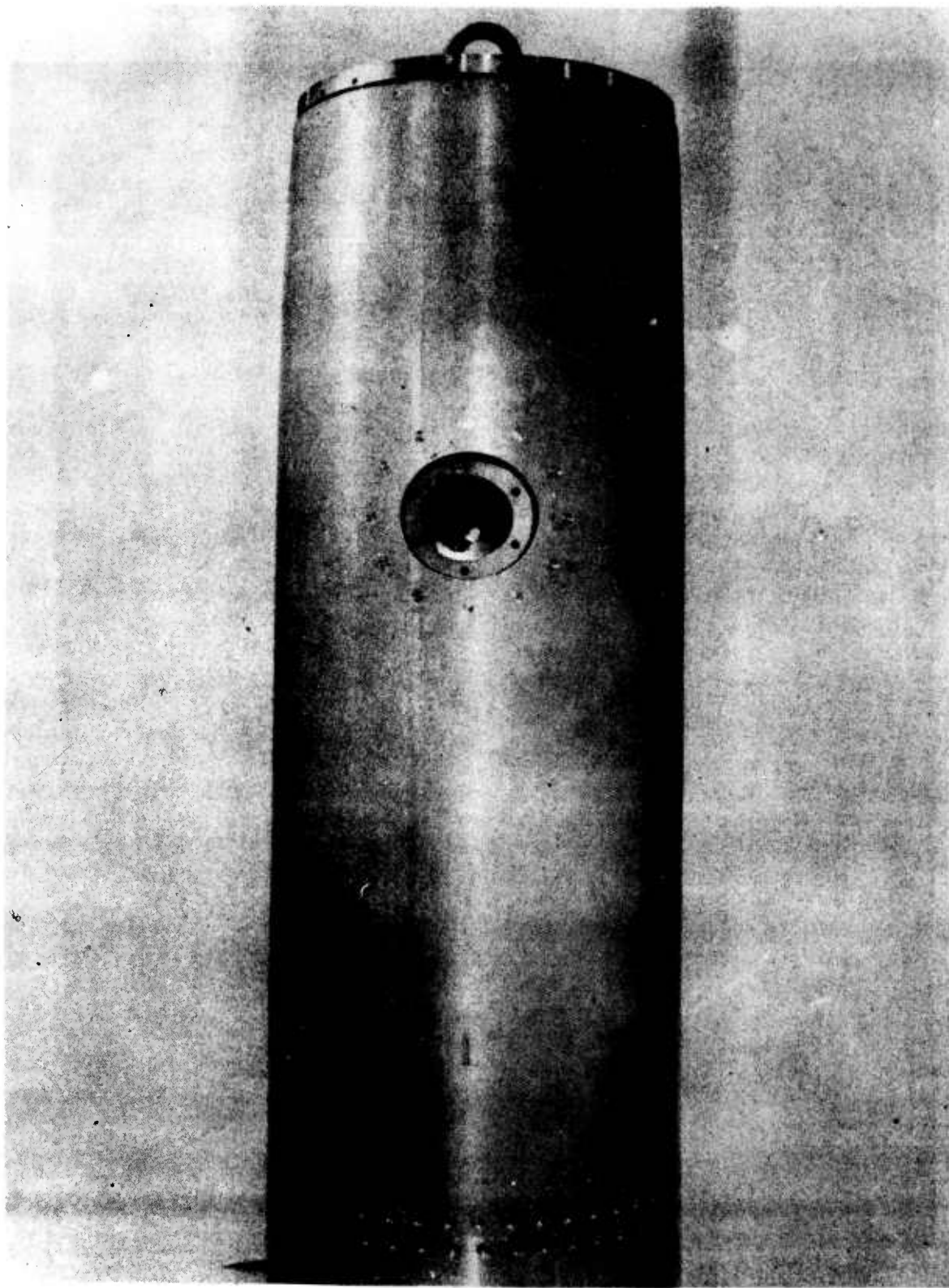


Figure 12. Rear Assembly

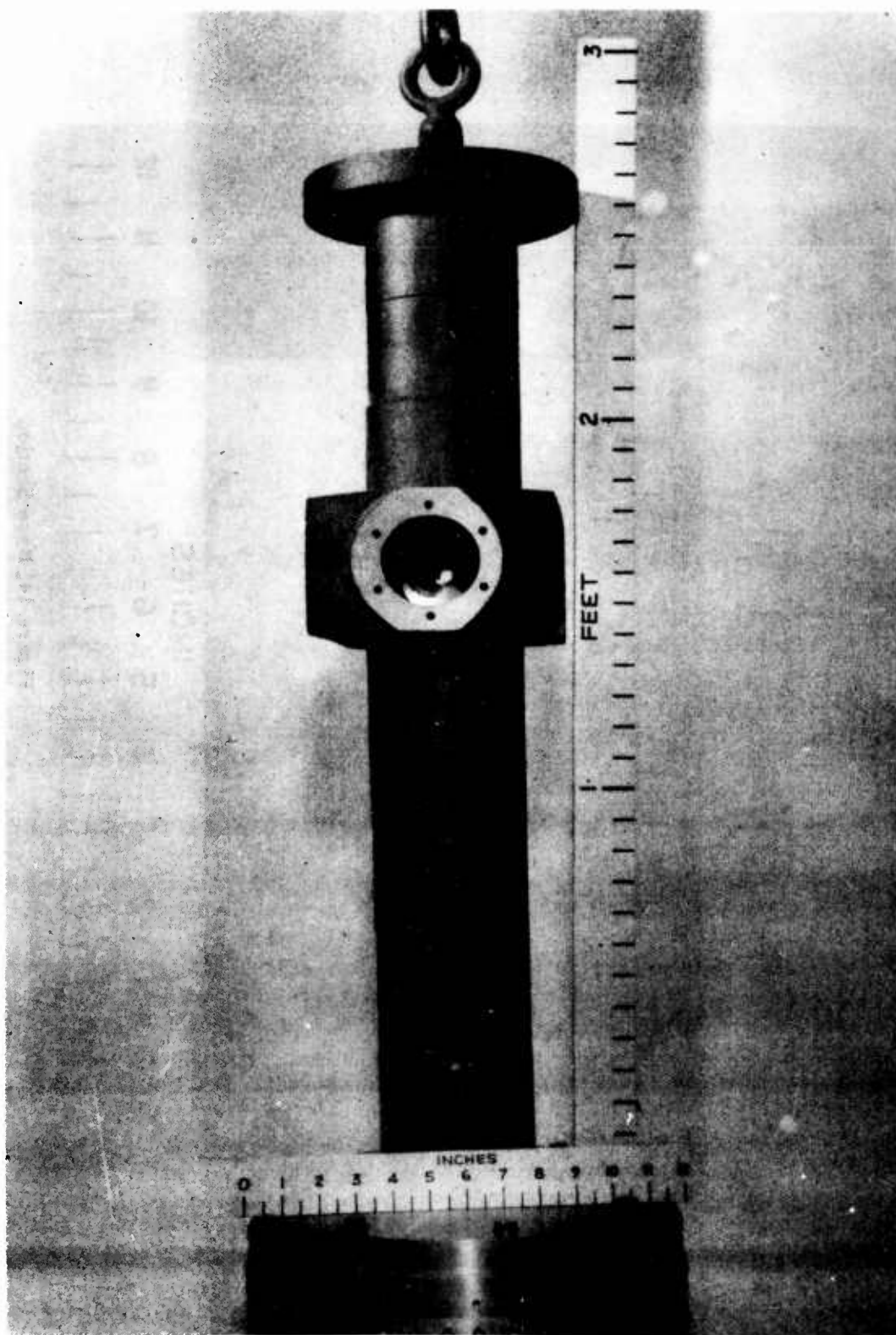


Figure 13. Ballast and Flash Charge Assembly

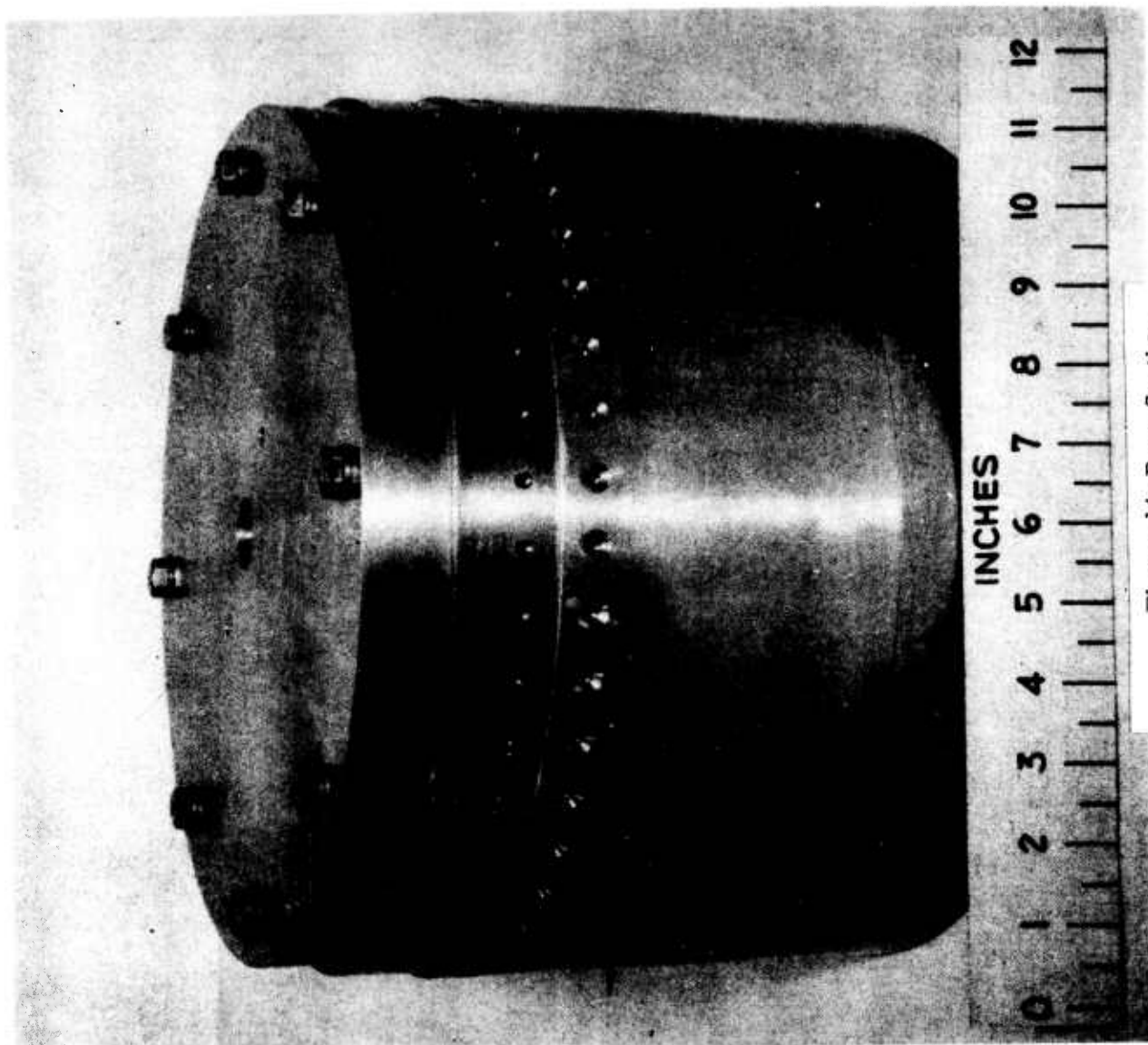


Figure 14. Base Section

APPENDIX B

TABLES

TABLE 1

TYPE A (MAXIMUM GAP) EXPLOSIVE TRAINS

MINIMUM TEMPERATURE TEST RESULTS

PART NO.	(INCH) AIR GAP		RESULTS			
	END A	END B	END A		END B	
			FIRE	FAIL	FIRE	FAIL
8849060	0.003	0.020*	X		X	
8850633	0.010*	0.008	X		X	
8849059	0.000*	0.005	X		X	
	0.003*	0.004	X		X	
8849060	0.004	0.011*	X		X	
8850633	0.006	0.008*		X	X	
8849059	0.007	0.001*		X	X	
	0.006	0.000*	-	-	-	-
8849060	0.003*	0.003	X		X	
8850633	0.003*	0.007	X		X	
8849059	0.000*	0.004	X		X	
	0.005	0.007*	X		X	
8849060	0.003	0.007*	X		X	
8850633	0.005	0.006*		X	X	
8849059	0.013*	0.007	X			X
	0.005	0.003*	-	-	-	-
8849060	0.003	0.007*	X		X	
8850633	0.003	0.006*	X		X	
8849059	0.005*	0.015	X		X	
	0.000	0.004*	X		X	
8849060	0.005	0.010*		X	X	
8850633	0.007*	0.004				X
8849059	0.007	0.004*	-	-	-	-
	0.000*	0.006	-	-	-	-
8849060	0.004	0.009*	X		X	
8850633	0.005	0.000*	X		X	
8849059	0.009*	0.008	X		X	
	0.005	0.009*	X		X	
8849060	0.002*	0.005	X			X
8850633	0.002*	0.003	X		X	
8849059	0.000*	0.005	X		X	
	0.006*	0.005		X	X	
8849060	0.000*	0.005	X		X	
8850633	0.004*	0.006	X			X
8849059	0.013*	0.006	X		X	
	0.006	0.013*		X	X	
8849060	0.004	0.000*	X		X	
8850633	0.005	0.000*	X		X	
8849059	0.000*	0.007	X		X	
	0.000*	0.005	X		X	

* Indicates propagation direction from booster to MDF
 - Indicates part was not initiated

TABLE 2

TYPE B (MINIMUM GAP) EXPLOSIVE TRAINS

MINIMUM TEMPERATURE TEST RESULTS

PART NO.	(INCH) AIR GAP		RESULTS			
	END A	END B	END A		END B	
			FIRE	FAIL	FIRE	FAIL
8849060	0.000	0.000	X		X	
8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
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8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
8849059			X		X	

TYPE B (MINIMUM GAP) EXPLOSIVE TRAINS

PART NO.	(INCH)		RESULTS			
	AIR GAP		END A		END B	
	END A	END B	FIRE	FAIL	FIRE	FAIL
8849060	0.000	0.000	X		X	
8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
8849059			X		X	
8849060			X		X	
8850633			X		X	
8849059			X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.011 ³⁴	X		X	
8849059	0.000	0.000	X		X	
8849060	0.000	0.000	X		X	
8850633	0.001 ³⁴	0.000	X		X	
8849059	0.000	0.000	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.018 ³⁴	X		X	
8849059	0.000	0.000	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	

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(continued)

TABLE 3 (CONT'D)

PART NO.	(INCH)		RESULTS			
	AIR GAP		END A		END B	
	END A	END B	FIRE	FAIL	FIRE	FAIL
8849060	0.000	0.011*	X		X	
8850633	0.000	0.011*	X		X	
8849059	0.000	0.000	X		X	
	0.000	0.000	X		X	
8849060	0.000	0.010*	X		X	
8850633	0.000	0.000	X		X	
8849059	0.011*	0.000	X		X	
	0.000	0.000	X		X	
8849060	0.000	0.011*	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
	0.000	0.000	X		X	
8849060	0.000	0.016*	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.011*	X		X	
	0.000	0.000	X		X	
8849060	0.001	0.011*	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
	0.000	0.000	X		X	
8849060	0.010*	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
	0.000	0.000	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.012*	X		X	
	0.000	0.000	X		X	
8849060	0.015*	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.013*	X		X	
	0.000	0.000	X		X	
8849060	0.002*	0.000	X		X	
8850633	0.009*	0.000	X		X	
8849059	0.000	0.000	X		X	
	0.000	0.000	X		X	
8849060	0.000	0.002*	X		X	
8850633	0.002*	0.000	X		X	
8849059	0.000	0.000	X		X	
	0.000	0.000	X		X	

* Indicates normal propagation direction from booster to MDF
 - Indicates part was not initiated

TABLE 3 (CONT'D)

PART NO.	(INCH) AIR GAP		RESULTS			
	END A	END B	END A		END B	
			FIRE	FAIL	FIRE	FAIL
8849060	0.000	0.002*	X		X	
8850633	0.000	0.009*	X		X	
8849059	0.000	0.000	X		X	
	0.000	0.000	X		X	
8849060	0.002*	0.000	X		X	
8850633	0.000	0.013*	X		X	
8849059	0.000	0.000	X		X	
	0.000	0.000	X		X	
8849060	0.002*	0.000	X		X	
8850633	0.000	0.009*	X		X	
8849059	0.000	0.000	X		X	
	0.000	0.000	X		X	
8849060	0.009*	0.000	X		X	
8850633	0.009*	0.000	X		X	
8849059	0.000	0.000	X		X	
	0.016*	0.000	X		X	
8849060	0.000	0.011*	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
	0.015*	0.000	X		X	

* Indicates normal propagation direction from booster to MDF

TABLE 4

TYPE A EXPLOSIVE TRAINS

AMBIENT TEMPERATURE TEST RESULTS

PART NO.	(INCH) AIR GAP		RESULTS			
	END A	END B	END A		END B	
			FIRED	FAILED	FIRED	FAILED
8849060	0.003	0.000*	X		X	
8850633	0.000*	0.008	X		X	
8849059	0.006	0.000*	X		X	
8849059	0.000*	0.005	X		X	
8849060	0.003	0.000*	X		X	
8850633	0.004	0.000*	X		X	
8849059	0.000*	0.008	X		X	
8849059	0.000*	0.003	X		X	
8849060	0.000*	0.003	X		X	
8850633	0.000*	0.007	X		X	
8849059	0.005	0.011*	X		X	
8849059	0.007	0.000*	X		X	
8849060	0.006	0.010*	X		X	
8850633	0.010*	0.006	X		X	
8849059	0.006	0.000*	X		X	
8849059	0.005	0.000*	X		X	
8849060	0.000*	0.004	X		X	
8850633	0.003	0.002*	X		X	
8849059	0.004	0.000*	X		X	
8849059	0.010*	0.006	X		X	
8849060	0.000*	0.003	X			X
8850633	0.009	0.004*	X		X	
8849059	0.000*	0.007	X			X
8849059	0.001*	0.008	-	-	-	-
8849060	0.007	0.000*	X		X	
8850633	0.003	0.000*	X		X	
8849059	0.000*	0.008	X		X	
8849059	0.000*	0.004	X		X	
8849060	0.003	0.000*	X		X	
8850633	0.003	0.000*	X		X	
8849059	0.002*	0.004	X		X	
8849059	0.005	0.004*	X		X	
8849060	0.003	0.000*	X		X	
8850633	0.000*	0.006	X		X	
8849059	0.005	0.011*	X		X	
8849059	0.006	0.018*	X		X	
8849060	0.004	0.000*	X		X	
8850633	0.001*	0.003	X		X	
8849059	0.006	0.004*	X		X	
8849059	0.008	0.011*	X		X	
8849060	0.000*	0.003	X		X	
8850633	0.000*	0.003	X		X	
8849059	0.008*	0.008	X		X	
8849059	0.000*	0.008	X		X	

* Indicates propagation direction from booster to MDF

- Indicates part was not initiated

(continued)

TABLE 4 (CONT'D)

PART NO.	(INCH) AIR GAP		RESULTS			
	END A	END B	END A		END B	
			FIRE	FAILED	FIRE	FAILED
8849060	0.011*	0.007	X		X	
8850633	0.000*	0.003	X		X	
8849059	0.000*	0.004	X		X	
8849059	0.002	0.003*	X		X	
8849060	0.007	0.000*	X		X	
8850633	0.006	0.000*	X		X	
8849059	0.006	0.005*	X		X	
8849059	0.007	0.000*	X		X	
8849060	0.004	0.005*	X		X	
8850633	0.003	0.018*	X		X	
8849059	0.000*	0.003	X		X	
8849059	0.000*	0.005	X		X	
8849060	0.004*	0.005	X		X	
8850633	0.008	0.010*	X		X	
8849059	0.003	0.000*	X		X	
8849059	0.003	0.000*	X		X	
8849060	0.007	0.000*	X		X	
8850633	0.004*	0.005	X		X	
8849059	0.003	0.000*	X		X	
8849059	0.000*	0.007	X		X	
8849060	0.004	0.000*	X		X	
8850633	0.006*	0.005	X		X	
8849059	0.002*	0.007	X		X	
8849059	0.006*	0.006	X		X	
8849060	0.010*	0.007	X			X
8850633	0.012*	0.006	X		X	
8849059	0.003	0.001*	-	-	-	-
8849059	0.007	0.000*		X	X	
8849060	0.005	0.012*	X		X	
8840633	0.011*	0.006	X		X	
8849059	0.006*	0.008	X		X	
8849059	0.003	0.002*	X		X	
8849060	0.008	0.011*		X	X	
8850633	0.003	0.010*		X	X	
8849059	0.004	0.002*	-	-	-	-
8849059	0.005	0.008*	-	-	-	-
8849060	0.011*	0.007	X		X	
8850633	0.007*	0.005	X		X	
8849059	0.000*	0.005	X		X	
8849059	0.006*	0.004	X		X	
8849060	0.002	0.012*	X		X	
8850633	0.000*	0.002	X		X	
8849059	0.009	0.010*	X		X	
8849059	0.002*	0.002	X		X	
8849060	0.016*	0.005	X		X	
8850633	0.000*	0.003	X		X	
8849059	0.013*	0.002	X		X	
8849059	0.003	0.008*	X		X	
8849060	0.002	0.000*	X		X	
8850633	0.009	0.012*	X		X	
8849059	0.002	0.000*	X		X	
8849059	0.005	0.002*	X		X	
8849060	0.010	0.010*	X		X	
8850633	0.002	0.013*	X		X	
8849059	0.002*	0.000	X		X	
8849059	0.002	0.001*	X		X	

* Indicates propagation direction from booster to MDF
 - Indicates part was not initiated

TABLE 5

TYPE A EXPLOSIVE TRAINS

DESERT STORAGE TEST RESULTS

PART NO.	(INCH) AIR GAP		RESULTS			
	END A	END B	END A		END B	
			FIRE	FAIL	FIRE	FAIL
8849060	0.019*	0.008	X		X	
8850633	0.005	0.010*	X		X	
8849059	0.000*	0.007	X		X	
8849059	0.000*	0.005	X		X	
8849060	0.010*	0.008	X		X	
8850633	0.002	0.000*	X		X	
8849059	0.000*	0.004	X		X	
8849059	0.005	0.000*	X		X	
8849060	0.004	0.011*	X		X	
8850633	0.007	0.009*	X		X	
8849059	0.006	0.000*	X		X	
8849059	0.003	0.017*	X		X	
8849060	0.005	0.000*	X		X	
8850633	0.007	0.017*	X		X	
8849059	0.006	0.010*	X		X	
8849059	0.008	0.000*	X		X	
8849060	0.003	0.000*	X		X	
8850633	0.007	0.009*	X		X	
8849059	0.000*	0.006	X		X	X
8849059	0.006	0.016*		X	X	
8849060	0.004	0.000*	X		X	
8850633	0.007	0.013*	X		X	
8849059	0.000*	0.004	X		X	
8849059	0.000*	0.007	X		X	
8849060	0.000*	0.002	X		X	
8850633	0.005	0.012*	X		X	
8849059	0.000	0.000*	X		X	
8849059	0.000*	0.008	X		X	
8849060	0.000*	0.001	X		X	
8850633	0.008	0.011*		X	X	
8849059	0.000*	0.009	X			X
8849059	0.000	0.009	-	-	-	-
8849060	0.008*	0.006	X		X	
8850633	0.005	0.000*	X		X	
8849059	0.000	0.000*	X		X	
8849059	0.000*	0.009	X		X	
8849060	0.007*	0.010	X		X	
8850633	0.003	0.002*	X		X	
8849059	0.000*	0.000	X		X	
8849059	0.000*	0.000	X		X	

* Indicates propagation direction from booster to MDF

- Indicates part was not initiated

TABLE 6

TYPE B EXPLOSIVE TRAINS
DESERT STORAGE TEST RESULTS

PART NO.	(INCH) AIR GAP		RESULTS			
	END A	END B	END A		END B	
			FIRE	FAIL	FIRE	FAIL
8849060	0.000	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849059	0.000	0.003	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849059	0.000	0.002	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.002	X		X	
8849059	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849060	0.000	0.000	X		X	
8850633	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	
8849059	0.000	0.000	X		X	

APPENDIX C

SHOCK AND VIBRATION TEST PROGRAM

SHOCK AND VIBRATION TEST PROGRAM

This test program was conducted to provide information concerning the structural integrity of the M8E1 Warhead, after being subjected to vibration and shock environments. The major condition of each test phase was as follows:

Handling Shock

27G for 11 milliseconds in all axes plus
47G for 11 milliseconds in the vertical axis

Transportation Vibration

5G maximum scan in vertical axis

Flight Vibration

5G, all axes

Flight Shock

60G for 35 milliseconds - longitudinal axis

TEST PROCEDURE

Inspection

Upon receipt of the test specimens, a visual inspection was conducted to insure that the warheads had arrived in an undamaged condition and were structurally acceptable for the test program.

HANDLING SHOCK

Setup

Six test units were selected for testing (Reference Figure 1). This testing was performed at General Dynamics/Convair (GD/C). An accelerometer was mounted on the shock table and connected to an oscilloscope.

Equipment

The following equipment was employed for this test:

<u>Equipment</u>	<u>Model No.</u>	<u>Serial No.</u>	<u>Cal. Due</u>	<u>Manuf.</u>
Medium Impact Shock Machine	1200 VD	109	...	Barry
Accelerometer	A5A-50-350	3976	12/27/61	Statham
Oscilloscope	104	GD/C E 295175	12/27/61	Hughes
Pre Amp	WB/4	GD/C E 517015-1	12/27/61	Hughes

Test

The six warheads were subjected to shock testing in each of three mutually perpendicular axes. These axes are identified in Figure 2. The shock forces were imparted as follows:

Vertical Axis (Figure 4)	Three 30G shocks in each direction pulse time - 12 milliseconds
	Two 50G shocks in each direction pulse time - 12 milliseconds
Transverse Axis (Figure 4)	Three 30G shocks in each direction pulse time - 12 milliseconds
Longitudinal Axis (Figure 3 and 5)	Three 30G shocks in each direction pulse time - 12 milliseconds

Results

Visual examination of the exterior of warheads disclosed no indication of structural failure.

TRANSPORTATION VIBRATION

Setup

Six warheads selected for this phase of the test program (Figure 1). A warhead was mounted in the vibration fixture in the vertical axis and attached to the vibration head. An accelerometer was attached, by means of dental cement, to the conical portion of the warhead.

Equipment

<u>Equipment</u>	<u>Model No.</u>	<u>Serial No.</u>	<u>Cal. Date</u>	<u>Manuf.</u>
Vibration Shaker	A246	20	----	Ling
Vibration Amplifier	PP20/24	--	30 Nov 61	Ling
Accelerometer	2213	CB84	4 Dec 61	Endevco
Accelerometer	2213	CB83	4 Dec 61	Endevco
Amplifier	2614	BB81	4 Dec 61	Endevco
Amplifier	2614	BB80	4 Dec 61	Endevco
Power Supply	2621	SLI 374	-----	Endevco

Test

The warheads were subjected to three vibration scans, along the vertical axis only, as follows:

<u>Frequency</u> <u>(cps)</u>	<u>Input G or Double</u> <u>Amplitude Displacement</u> <u>(inches)</u>
5 7.75	0.4
7.25 - 23	1 G
23 - 54	0.036
54 -200	5 G

Each of the three vibration scans had a time duration of 15 minutes.

In addition to the above, a three-minute resonant dwell was conducted at frequencies where the amplification factor was greater than two.

Results

Visual examination of the exterior of the warheads disclosed no indications of structural failure.

Unit 5 - One emitted noise during test, but no damage could be found. No resonant shifts which might evidence internal structure failure were observed.

FLIGHT VIBRATION

Setup

Six warheads were selected for the flight vibration phase of the test program (Reference Figure 1). A warhead was installed in the vibration jig and attached to the vibration head.

Equipment

<u>Equipment</u>	<u>Model</u> <u>No.</u>	<u>Serial</u> <u>No.</u>	<u>Cal.</u> <u>Date</u>	<u>Manuf.</u>
Vibration Shaker	A 246	20	-----	Ling
Vibration Amplifier	PP 20/24	---	30 Nov 61	Ling
Accelerometer	2213	CB84	4 Dec 61	Endevco
Accelerometer	2213	CB83	4 Dec 61	Endevco
Amplifier	2614	BB81	4 Dec 61	Endevco
Amplifier	2614	BB80	4 Dec 61	Endevco
Power Supply	2621	SLI 374	-----	Endevco

Test

The warhead was vibrated, in each of three mutually perpendicular axes, for one cycle per axis. A cycle was defined as 5 Gs applied from 75 cps in three minutes.

Results

Visual examination of the exterior of the warheads disclosed no indications of structural failure.

Unit 5 - One emitted noise during test, but no indication of damage could be found.

FLIGHT SHOCK

Setup

Six warheads were subjected to the flight shock test (Reference Figure 1).

This test was conducted at American Laboratories, utilizing a pendulum-type shock machine. The warhead was shock tested in the longitudinal axis only.

Test

Each of the six specimens was subjected to a single shock of 60 G, with a 36 millisecond time duration. This was accomplished by raising the pendulum 59 inches above the ground and allowing it to free fall against a rubber pad.

Results

Visual examination disclosed no indications of structural failure.

INITIATION OF SPOTTING CHARGES

Setup

The warheads were placed in a saddle with the longitudinal axis parallel to the ground.

Test

A dynamite cap was positioned over the exposed end of the fuze train in the timer section of the warhead. The objective of the test was to note only whether the two spotting charges would ignite, after ignition of the fuze train by the dynamite cap. The dynamite cap was actuated by a 6-volt battery.

Results

Both spotting charges ignited in all 10 warheads. In all cases, a large quantity of white smoke and burning particles were emitted.

ABSTRACT DATA

ABSTRACT

Accession No. _____ AD _____

Picatinny Arsenal, Dover, New Jersey

PRODUCT IMPROVEMENT STUDY FOR WARHEAD
SECTION, 318MM ROCKET, PRACTICE: M8E1

Wilfred Truran

Technical report 3081, October 1963, 47 pp, tables,
figures. Unclassified report from the Ammunition
Engineering Laboratory, Ammunition Engineering
Directorate.

A study was conducted to incorporate into the M8
R&D Practice Warhead, improved production proc-
esses and techniques, cost reduction, substitution
of common T54E1 Tactical Warhead parts, where
possible, and minor and major design improve-
ments without sacrificing safety or reliability.

When using parts common to the T54E1 Tactical
Warhead, the production-engineered M8E1 Warhead
resulted in reduction of cost over the M8 design.

It was recommended that the M8E1 design be utilized
in all future procurements, should be type classified
as Standard A, and assigned the nomenclature: War-
head Section, 318mm Rocket, Practice: M8A1.

UNCLASSIFIED

1. Rockets, 318mm
2. Training Ammunition

- I. Truran, Wilfred
- II. M8E1 rocket

UNITERMS

Design
Warhead
318mm
Practice
Rocket
M8E1
Truran, W.

Accession No. _____ AD _____
Picatinny Arsenal, Dover, New Jersey

**PRODUCT IMPROVEMENT STUDY FOR WARHEAD
SECTION, 318 MM ROCKET, PRACTICE: M8E1**

Wilfred Turan

Technical Report 3081, October 1963, 47 pp, tables, figures.
Unclassified report from the Ammunition Engineering Laboratory, Ammunition Engineering Directorate.

A study was conducted to incorporate into the M8 R & D Practice Warhead, improved production processes and techniques, cost reduction, substitution of common T54E1 Tactical warhead parts, where possible, and minor and major design improvements without sacrificing safety or reliability.

(over)

UNCLASSIFIED

1. Rockets, 318 mm
2. Training Ammunition
- I. Turan, Wilfred
- II. M8E1 rocket

UNITERMS

Design
Warhead
318 mm
Practice
Rocket
M8E1
Turan, W.

UNCLASSIFIED

Accession No. _____ AD _____
Picatinny Arsenal, Dover, New Jersey

**PRODUCT IMPROVEMENT STUDY FOR WARHEAD
SECTION, 318 MM ROCKET, PRACTICE: M8E1**

Wilfred Turan

Technical Report 3081, October 1963, 47 pp, tables, figures.
Unclassified report from the Ammunition Engineering Laboratory, Ammunition Engineering Directorate.

A study was conducted to incorporate into the M8 R & D Practice Warhead, improved production processes and techniques, cost reduction, substitution of common T54E1 Tactical warhead parts, where possible, and minor and major design improvements without sacrificing safety or reliability.

(over)

UNCLASSIFIED

1. Rockets, 318 mm
2. Training Ammunition
- I. Turan, Wilfred
- II. M8E1 rocket

UNITERMS

Design
Warhead
318 mm
Practice
Rocket
M8E1
Turan, W.

UNCLASSIFIED

Accession No. _____ AD _____
Picatinny Arsenal, Dover, New Jersey

**PRODUCT IMPROVEMENT STUDY FOR WARHEAD
SECTION, 318 MM ROCKET, PRACTICE: M8E1**

Wilfred Turan

Technical Report 3081, October 1963, 47 pp, tables, figures.
Unclassified report from the Ammunition Engineering Laboratory, Ammunition Engineering Directorate.

A study was conducted to incorporate into the M8 R & D Practice Warhead, improved production processes and techniques, cost reduction, substitution of common T54E1 Tactical warhead parts, where possible, and minor and major design improvements without sacrificing safety or reliability.

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2. Training Ammunition
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- II. M8E1 rocket

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